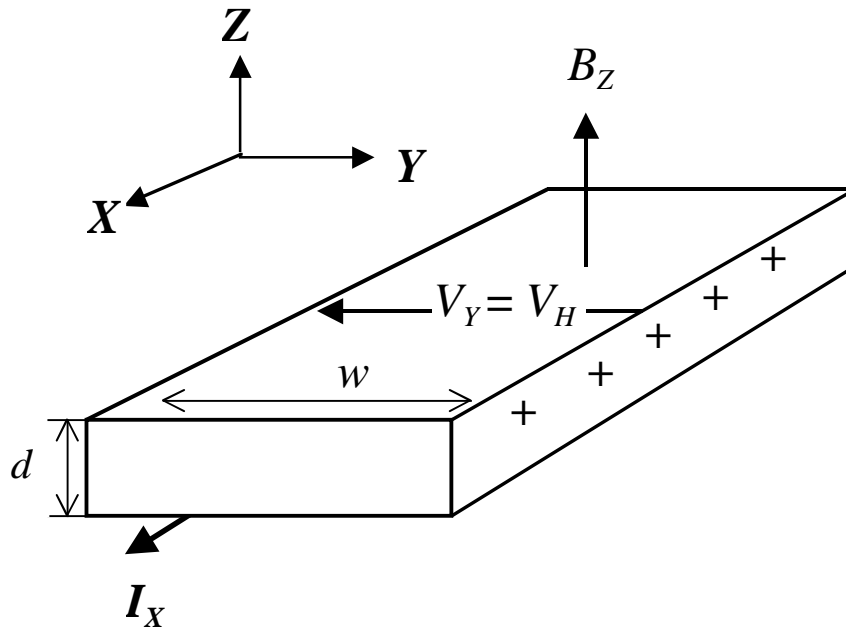


1.6 Hall Effect: measurement of carrier concentration in metals and semiconductors

For a Hall effect measurement, the arrangement is:



Force $q(\mathbf{v} \times \mathbf{B})$ pushes electrons in y -direction leaving net +ve charge on one face, as shown. This charge separation produces the Hall voltage, V_H

Note: the directions of I , B and V are important – this is why the x, y, z axes are given in the above diagram for orientation.

When the Hall voltage is established the force on the electrons is balanced, so that

$$eE_y = -B_z e v_x$$

From $I = nAve$ we see the current density J is

$$J_x = \frac{I_x}{A} = nev_x$$

The subscripts on J , I and v give their directions. Since $\mathbf{J} = \sigma \mathbf{E}$ where σ is the conductivity, we have

$$J_x = \frac{I}{A} = \sigma E_x = nev_x$$

Rearranging these we find that

$$E_y = -\frac{B_z J_x}{ne} = -\frac{B_z E_x \sigma}{ne}$$

Note that

$$E_y = \frac{V_y}{w} = \frac{V_H}{w}$$

where w is the width of the specimen in metres.

So, if the current, I , and magnetic field, B , are known, measurement of the Hall voltage V_H gives us the electron concentration n :

$$n = -\frac{B_z J_x}{E_y e} = -\frac{w B_z J_x}{V_H e}$$

or

$$n = -\frac{w B_z I_x}{A V_H e}$$

where A is the cross-sectional area of the specimen.

Since $A = w \times d$ (cross-sectional area A = width w times thickness d) we can also write,

$$n = -\frac{B_z I_x}{d V_H e}$$

giving carrier concentration n in terms of magnetic induction B, current I, Hall voltage V_H and electronic charge e.